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Endoparasites of Cope's Gray Treefrog, *Hyla chrysoscelis,* and Western Chorus Frog, *Pseudacris t. triseriata,* from Southeastern Wisconsin

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ABSTRACT: Sixty-five Cope's gray treefrogs, *Hyla chrysoscelis,* and 6 western chorus frogs, *Pseudacris t. triseriata,* were collected from southeastern Wisconsin during April through June 1996 and 1997 and examined for endoparasites. Fifty-one (78%) treefrogs and 5 (83%) chorus frogs were infected with 1 or more endoparasites. Two species of protozoa, 2 species of nematodes, 3 species of larval and adult digeneans, 1 species of monogenean, and 3 species of metacestodes infected the treefrogs. The chorus frogs were infected by 1 species of protozoan, 1 species of nematode, and 2 species of larval and adult digeneans. New host and distribution records for protozoan and metazoan parasites of Wisconsin anurans are reported.

KEY WORDS: *Hyla chrysoscelis, Pseudacris t. triseriata, Opalina* sp., *Nyctotherus cordiformis, Polystoma nearcticum, Glypthelmins pennsylvaniensis, Mesocestoides* sp., *Cosmocercoides variabilis, Oswaldocruzia pipiens,* Wisconsin.

Cope's gray treefrog, *Hyla chrysoscelis* Cope, 1880, is a large treefrog occurring in prairie ponds, oak savannas, dry and dry-mesic northern hardwoods, and lowland forests and has been distinguished from the eastern gray treefrog, *H. versicolor* Le Conte, 1825 (Ralin, 1968). Because of the similarity between these two species, different ranges have not been determined and little information on the natural history of *H. chrysoscelis* is available (Ralin, 1968; Jaslow and Vogt, 1977). The composite range covers most of the eastern United States from Ontario and southern Maine to the Gulf of Mexico (Vogt, 1981). The western chorus frog, *Pseudacris t. triseriata* Wied, 1839, is a small treefrog that ranges from the east end of Lake Ontario, west to central Minnesota, and south through Kansas and Oklahoma, with disjunct populations in New Mexico and Arizona (Vogt, 1981). A number of studies have been conducted on the endoparasites of the western chorus frog, but only two prior studies have been conducted on Cope's gray treefrog (see Table 1). Both species are common around moist prairies in southeastern Wisconsin, yet no studies exist on their endoparasites in this area. Here we present new information on the parasites of Wisconsin treefrogs.

Materials and Methods

Between May and June 1996 and April and June 1997, 65 Cope's gray treefrogs, 53 males and 12 females (mean ± SD snout–vent length [SVL] = 41 ± 3 mm, range = 33–48 mm) and 6 western chorus frogs, 4 males and 2 females (24 ± 1 mm, 22–25 mm) were collected from two adjacent ephemeral ponds in Waukesha County, Wisconsin (42°54′N, 88°29′W). Cope's gray treefrogs were identified by mating call and mean erythrocyte length, as described by Bolek (1997). Specimens were collected by hand or dip-net during the night breeding chorus. Animals were transported to the laboratory and euthanized in MS 222 (ethyl m-aminobenzoate methane sulfonic acid) within 72 hr of capture. SVL and wet weight (WW) were recorded for each individual. At necropsy the digestive tract, limb and body wall musculature, and internal organs were examined for endoparasites. Intestinal protozoans were affixed to glass slides with albumin fixative and glycerol, fixed in modified Schaudinn's fixative, stained with hematoxylin, dehydrated in a graded ethanol series, cleared in xylene, and mounted in Canada balsam. Nonencapsulated immature and adult digeneans and cestodes were relaxed and killed by slowly warming them in staining dishes containing 0.25% saline and then fixed in alcohol–formaldehyde–acetic acid (AFA). Monogeneans were relaxed under slight coverslip pressure in a refrigerator and then frozen and fixed in AFA, stained with acetocarmine, dehydrated in a graded ethanol series, cleared in xylene, and mounted in Canada balsam. Nematodes were killed in hot AFA, dehydrated to 70% ethanol, cleared in glycerol, and identified as temporary mounts. All tissue containing metacestodes was removed and fixed in 10% formalin, embedded in Paraplast, sectioned at 7 μm, affixed to slides, stained with Harris's hematoxylin and eosin, and mounted in Canada balsam. All undigested stomach contents were identified to taxonomic class or order following Borror et al. (1989). Stomach contents were reported as a percentage, i.e., number of arthropods in a given class or order divided by total number of arthropods recovered. Prevalence, mean intensity, and abundance are according to Bush

Table 1. Endoparasites reported from *Hyla chrysoscelis* and *Pseudacris t. triseriata*.

Parasite species	*Hyla chrysoscelis*		*Pseudacris t. triseriata*	
	Locality	Reference	Locality	Reference
Protozoa				
Opalina sp.	Wisconsin	This study		
	Texas	Metcalf, 1923		
O. obtrigonoidea			Ohio	Odlaug, 1954
O. chorophili			Ohio	Odlaug, 1954
Cepedea sp.	Texas	Metcalf, 1923		
Nyctotherus cordiformis	Wisconsin	this study	Ohio	Odlaug, 1954
			Wisconsin	this study
Trichomonas augusta			Ohio	Odlaug, 1954
Digenea				
Brachycoelium salamandrae			Ohio	Odlaug, 1954
Glypthelmins hyloreus			Colorado	Ubelaker et al., 1967
			Nebraska	Brooks, 1976
G. pennsylvaniensis	Wisconsin	this study	Michigan	Muzzall and Peebles, 1991
			Wisconsin	this study
G. quieta			Ohio	Ashton and Rabalais, 1978
Glypthelmins sp.			Indiana	Whitaker, 1971
Haematoloechus complexus	Nebraska	Brooks, 1976		
Megalodiscus temperatus	Nebraska	Brooks, 1976		
Unidentified immature trematode	Wisconsin	this study		
Unidentified metacercariae	Wisconsin	this study	Wisconsin	this study
Monogenea				
Polystoma nearcticum	Wisconsin	this study		
Cestoidea				
Mesocestoides sp.	Wisconsin	this study		
Unidentified plerocercoid	Wisconsin	this study		
Unidentified cestode cyst	Wisconsin	this study		
Nematoda				
Cosmocercoides variabilis	Wisconsin	this study	Ohio	Odlaug, 1954
			Wisconsin	this study
			Texas	Harwood, 1930
			Canada	Vanderburgh and Anderson, 1987a
C. dukae			Ohio	Ashton and Rabalais, 1978
			Michigan	Muzzall and Peebles, 1991
Oswaldocruzia pipiens	Wisconsin	this study	Canada	Baker, 1977
O. leidyi			Ohio	Ashton and Rabalais, 1978
Falcaustra catesbeianae			Arizona	Goldberg et al., 1996
Gyrinicola batrachiensis†			Canada	Adamson, 1981
Rhabdias ranae			Canada	Baker, 1978b

† In tadpoles.

et al. (1997). Voucher specimens have been deposited in the H. W. Manter Helminth Collection, University of Nebraska State Museum, Lincoln (accession numbers HWML 39468, *Opalina* sp.; 39483, *Nyctotherus cordiformis*; 39469, *Polystoma nearcticum*; 39470, *Glypthelmins pennsylvaniensis*; 39471, immature trematode; 39472, unidentified metacercariae; 39473, unidentified plerocercoid; 39474, *Mesocestoides* sp.; 39482, unidentified cestode cyst; 39475, male *Cosmocercoides variabilis*; 39476, male *Oswaldocruzia pipiens*).

Results and Discussion

Eleven species of endoparasites infected Cope's gray treefrogs and 4 species infected western chorus frogs (Table 2). Of the 51 (78%) treefrogs infected with endoparasites, 26 harbored only 1 species, 19 harbored 2 species, and 6 harbored 3 species. Prevalence ranged from 52% for *Opalina* sp. to 1.5% for *Glypthelmins pennsylvaniensis* Cheng, 1961. Overall mean

Table 2. Prevalence, abundance, and mean intensity of endoparasites of *Hyla chrysoscelis* and *Pseudacris t. triseriata* from southeastern Wisconsin.

	Hyla chrysoscelis			*Pseudacris t. triseriata*			
	Prevalence*	Mean (±SD) abundance	Mean (±SD) intensity (range)	Prevalence*	Mean (±SD) abundance	Mean (±SD) intensity (range)	Location†
Protozoa							
Opalina sp.	34 (52)	NC‡	NC	absent	absent	absent	SI, LI
Nyctotherus cordiformis	5 (8)	NC	NC	1 (17)	NC	NC	SI, LI
Monogenea							
Polystoma nearcticum	10 (15)	0.2 ± 0.5	1.3 ± 0.7 (1–3)	absent	absent	absent	UB
Digenea							
Glypthelmins pennsylvaniensis	1 (1.5)	0.02 ± 0.1	1	3 (50)	1 ± 1.5	2 ± 1.7 (1–4)	SI
Unidentified immature trematode	3 (5)	2 ± 9	42.3 ± 3 (39–45)	absent	absent	absent	SI
Unidentified metacercariae	5 (8)	1.3 ± 8.7	16.8 ± 29.6 (1–69)	1 (17)	1 ± 2.4	6	LM, BC
Cestoidea							
Unidentified plerocercoid	1 (1.5)	0.2 ± 1.7	14	absent	absent	absent	BC, L
Unidentified cestode cyst	1 (1.5)	0.1 ± 0.9	7	absent	absent	absent	S
Mesocestoides sp.	8 (12)	NC	NC	absent	absent	absent	BC, SI, LI, LV, M
Nematoda							
Cosmocercoides variabilis	14 (22)	0.7 ± 3	3.3 ± 5 (1–23)	4 (67)	1 ± 0.9	1.5 ± 0.6 (1–2)	SI, LI, L
Oswaldocruzia pipiens	4 (6)	0.08 ± 0.3	1.3 ± 0.5 (1–2)	absent	absent	absent	SI

* Number (%) infected.
† BC = body cavity; L = lungs; LI = large intestine; LM = leg muscles; LV = liver; M = musculature; S = stomach; SI = small intestine; UB = urinary bladder.
‡ NC = not counted.

helminth abundance for all worm species that could be counted accurately in the treefrogs was 4.4 ± 12.9. Of the 5 (83%) infected chorus frogs, 2 harbored 1 species, 2 harbored 2 species, and 1 harbored 3 species. Prevalence and mean intensities were highest for *Cosmocercoides variabilis* Harwood, 1930, and *G. pennsylvaniensis*. Overall mean helminth abundance in the chorus frogs was 3.0 ± 3.3. There was no significant correlation ($P > 0.05$) between helminth abundance for any of the worm species that could be counted accurately and WW or SVL for treefrogs or chorus frogs. Twenty-nine (45%) treefrogs had identifiable stomach contents, but only 2 chorus frogs had stomach contents. The treefrog diet consisted of insects, with coleopterans making up 43% of the diet followed by lepidoptera larvae (24%), unidentifiable insects (22%), and orthopterans (11%). The stomachs of the 2 chorus frogs contained coleopterans and unidentifiable arthropods.

The protozoan *Opalina* sp. Purkinje and Valentin, 1840, was found in the small and large intestine of the treefrogs. These protozoans were not identified to species because of lack of range of forms as suggested by Sandon (1976). *Opalina* spp. were previously reported in *H. chrysoscelis* from Texas by Metcalf (1923) and the sister species *H. versicolor* from various locations in the midwestern and southern parts of the United States. The absence of *Opalina* sp. from the western chorus frogs may be due to the small sample of frogs collected. A number of previous reports have shown that the western chorus frog and other *Pseudacris* species harbor these protozoans (Metcalf, 1923; Brandt, 1936; Odlaug, 1954; McAllister, 1987, 1991).

Nyctotherus cordiformis Ehrenberg, 1838, infected both host species in this study. These ciliates are common parasites of *Hyla* and *Pseudacris* (Brandt, 1936; McAllister, 1987, 1991; McAllister et al., 1993) and have been reported previously from *H. versicolor* from a number of locations throughout its range, although the prevalence reported was much higher than that in this study (Wichterman, 1936; Campbell, 1968). *Hyla chrysoscelis* is a new host record for this ciliate. Prevalence of infection in this hylid species was more comparable to that of terrestrial anurans such as *Bufo* (Campbell, 1968; McAllister et al., 1989) and may reflect differences in habitat utilization from *H. versicolor*. Blair (1958) reported that *H. chrysoscelis* is a grassland species in parts of its range, whereas in Wisconsin its distribution in general corresponds to prairies, oak savannas, and pine savannas (Jaslow and Vogt, 1977). Another explanation for the low prevalence observed may be the time of year these frogs were collected. Brandt (1936) reported low prevalence of this ciliate in *Pseudacris* and *Hyla* during early summer.

Polystoma nearcticum Paul, 1938, infected the urinary bladder of *H. chrysoscelis*. This species has been reported previously from *H. versicolor* from Minnesota and *H. cinerea* Schneider, 1799, the green treefrog, from Florida (Paul, 1938). Brooks (1976), in his survey of Nebraska amphibians, found no *H. chrysoscelis* infected with this monogenean. *Hyla chrysoscelis* is a new host record and Wisconsin is a new locality record for *P. nearcticum*.

Three chorus frogs and 1 treefrog were infected with *G. pennsylvaniensis*. This trematode has been reported from Wisconsin spring peepers, *P. c. crucifer* Wied, 1839, by Coggins and Sajdak (1982) and Yoder and Coggins (1996). This is the first report from Wisconsin chorus frogs and the first report from Cope's gray treefrogs.

Three treefrogs were infected with an unidentified immature digenean located in the small intestine. These trematodes were small and showed some development of testes and ovary, but vitellaria, genital pore, or uterus could not be seen. Both frog species were infected at low prevalence with an unidentified metacercaria located in the leg muscles and body cavity. Metacercariae have previously been reported at low prevalence from leg muscle and body cavity musculature in other *Hyla* and *Pseudacris* species (Ulmer, 1970; Yoder and Coggins, 1996).

Ten treefrogs were infected with numerous metacestodes. Eight of the 10 treefrogs were heavily infected with tetrathyridia of *Mesocestoides* sp. Valunt, 1863. These organisms were encapsulated in the intestine, liver, and musculature, but a few were also found free in the body cavity. Three of the treefrogs harbored heavy infections under the skin of the hind legs, with as many as 300 metacestodes/leg. These treefrogs displayed small abrasions on the outer surface of the skin, which appeared red or pink in color instead of the usual cream white color. Although a number of bufonids and ranids have been reported to be infected with *Mesocestoides*

sp. (see McAllister et al., 1989; McAllister and Conn, 1990; McAllister et al., 1995) only one hylid is known to be infected with this metacestode (McAllister, 1987). Therefore, Cope's gray treefrog is a new host record. Two other Cope's gray treefrogs were infected with other unidentified metacestodes; 1 treefrog harbored 14 plerocercoids, 13 in the body cavity and 1 in a lung. All metacestodes possessed a tetracetabulate scolex with an apical organ. The other treefrog possessed 7 cestode cysts on the outer mesentery of the stomach. These cestodes lacked an excretory antrum and did not appear to be *Mesocestoides* sp. Plerocercoids and other cestode cysts have been previously reported from *H. versicolor* in Missouri and other hylids from North Carolina (Brandt, 1936; Shannon, 1988).

Two species of nematodes, *Oswaldocruzia pipiens* Walton, 1929, and *Cosmocercoides variabilis* Harwood, 1930, infected Cope's gray treefrog, and *C. variabilis* infected the western chorus frogs. Four male and 1 gravid female *O. pipiens* were found in the small intestine of 4 treefrogs. Cope's gray treefrog is a new host record for *O. pipiens*.

A total of 46 *C. variablis* (16 males, 20 females, and 10 J_4 larvae) were recovered from 14 of the treefrogs, and 6 (1 male, 3 females, and 2 J_4 larvae) were recovered from 4 of the chorus frogs. Vanderburgh and Anderson (1987a) reported that *C. variabilis* is a parasite of amphibians but *C. dukae* Holl, 1928, is a parasite of terrestrial molluscs, with inadvertent occurrences in animals that feed upon terrestrial molluscs (Anderson, 1960). The major difference in the 2 nematode species is the number of rosette papillae per subventral row in males; male *C. dukae* have 9–21 rosette papillae (averaging 13 or 14) and *C. variabilis* have 15–25 (averaging 20 or 21). All males in the present study possessed 17–23 rosette papillae, averaging 19.6. Measurements of gubernaculum length of males and esophagus length and bulb width for males and females fell in the ranges for those measurements in *C. variabilis* as given by Vanderburgh and Anderson (1987a) for toads. The J_4 larvae were also located in the lungs and small intestine, and all adult females were gravid with developing larvae in the eggs. The diet of Cope's gray treefrog, as indicated by this study and previous work (Ralin, 1968), consists mostly of insects, and molluscs probably play an insignificant role if any in their diet. Therefore, the specimens collected in the present study probably are *C. variabilis*. This nematode has a direct life cycle that includes skin penetration, molting in the lungs or body cavity, and maturing in the intestine (Baker, 1978c). It was suggested that this parasite may be restricted to certain amphibian groups such as hylids, microhylids, and bufonids (Vanderburgh and Anderson, 1987a). *Cosmocercoides variabilis* is a common parasite of the eastern American toad *Bufo a. americanus* Holbrook, 1836 (Vanderburgh and Anderson, 1987a, b; Joy and Bunten, 1997), and has previously been reported from the western chorus frog in Canada (Vanderburgh and Anderson, 1987a). This is the first report from Cope's gray treefrog and the first report from Wisconsin chorus frogs.

The breeding pond probably serves as the most important focus of infection with these endoparasite species, and diet of adult frogs plays a lesser role. Brandt (1936) suggested that an arboreal habitat is less conductive to metazoan parasitism than are terrestrial or aquatic habitats. The arboreal nature of Cope's gray treefrogs probably has an effect on parasite colonization during the tadpole stage or breeding period of these frogs. Of the 11 endoparasites recovered, 6 have been reported to have their life cycles synchronized to the amphibian tadpole stage and their emergence period from the pond (Brandt, 1936; Wichterman, 1936; Paul, 1938; Cheng, 1961; El Mofty and Smyth, 1964; El Mofty, 1973; Sullivan and Byrd, 1970; Baker, 1978a). The 3 metacestode species recovered are probably acquired by frogs feeding on intermediate hosts. Stomach content analysis revealed that the diet of these frogs is less diverse than that of other Wisconsin anurans (Vogt, 1981). Accordingly, endoparasites dependent on intermediate hosts were found at a lower prevalence in these hosts than in other Wisconsin frogs (Williams and Taft, 1980; Coggins and Sajdak, 1982; Yoder and Coggins, 1996).

Results of the current survey support previous work on treefrog endoparasites, indicating that most are not host specific. In the present study, both frogs utilized the same breeding ponds, with the western chorus frog breeding from late March to late June and Cope's gray treefrog breeding from mid May to late June (pers. obs.). Because of the overlap in habitat utilization by adults and tadpoles of these hosts, transmission of parasites between them is likely. Although

prevalence, mean intensity, and mean abundance was not compared among the two host species because of the low number of chorus frogs examined, the 2 hosts shared 4 endoparasite species, and 2 other species found in Cope's gray treefrogs have been previously reported in western chorus frogs (Metcalf, 1923; Baker, 1977). *Polystoma nearcticum* is the only parasite in this study that is host specific to the genus *Hyla* and has not been reported in *Pseudacris* (see Paul, 1938; Campbell, 1968). Therefore, despite the occurrence of some parasite species in certain amphibian hosts, if the opportunity arises, some parasites are capable of infecting several different host species, confirming that ecological influences can affect host specificity (Prudhoe and Bray, 1982).

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Literature Cited

Adamson, M. L. 1981. *Gyrinicola batrachiensis* (Walton, 1929) n. comb. (Oxyuroidea; Nematoda) from tadpoles in eastern and central Canada. Canadian Journal of Zoology 59:1344–1350.

Anderson, R. C. 1960. On the development and transmission of *Cosmocercoides dukae* of terrestrial mollusks in Ontario. Canadian Journal of Zoology 38:801–825.

Ashton, A. D., and R. C. Rabalais. 1978. Helminth parasites of some anurans of northwestern Ohio. Proceedings of the Helminthological Society of Washington 45:141–142.

Baker, M. R. 1977. Redescription of *Oswaldocruzia pipiens* Walton, 1929 (Nematoda: Trichostrongylidae) from amphibians of eastern North America. Canadian Journal of Zoology 55:104–109.

———. 1978a. Development and transmission of *Oswaldocruzia pipiens* Walton, 1929 (Nematoda: Trichostrongylidae) in amphibians. Canadian Journal of Zoology 56:1026–1031.

———. 1978b. Morphology and taxonomy of *Rhabdias* spp. (Nematoda: Rhabdiasidae) from reptiles and amphibians of southern Ontario. Canadian Journal of Zoology 56:2127–2141.

———. 1978c. Transmission of *Cosmocercoides dukae* (Nematoda: Cosmocercoidea) to amphibians. Journal of Parasitology 64:765–766.

Blair, W. F. 1958. Mating call in the speciation of anuran amphibians. American Naturalist 92:27–51.

Bolek, M. G. 1997. Geographic distribution. *Hyla chrysoscelis*. Herpetological Review 28:93.

Borror, D. J., C. A. Triplehorn, and N. F. Johnson. 1989. An Introduction to the Study of Insects, 6th ed. Harcourt Brace College Publishers, Philadelphia. 875 pp.

Brandt, B. B. 1936. Parasites of certain North Carolina salientia. Ecological Monographs 6:491–532.

Brooks, D. R. 1976. Parasites of amphibians of the great plains. 2. Platyhelminths of amphibians in Nebraska. Bulletin of the University of Nebraska State Museum 10:65–92.

Bush, A. O., K. D. Lafferty, J. M. Lotz, and A. W. Shostak. 1997. Parasitology meets ecology on its own terms: Margolis et al. revisited. Journal of Parasitology 83:575–583.

Campbell, R. A. 1968. A comparative study of the parasites of certain salientia from Pocahontas State Park, Virginia. Virginia Journal of Science 19:13–29.

Cheng, T. C. 1961. Description, life history and developmental pattern of *Glypthelmins pennsylvaniensis* n. sp. (Trematoda: Brachycoeliidae), new parasite of frogs. Journal of Parasitology 47:469–477.

Coggins, J. R., and R. A. Sajdak. 1982. A survey of helminth parasites in the salamanders and certain anurans from Wisconsin. Proceedings of the Helminthological Society of Washington 49:99–102.

El Mofty, M. M. 1973. Induction of sexual reproduction in *Opalina sudafricana* by injecting its host (*Bufo regularis*) with nicotine. International Journal for Parasitology 1973:265–266.

———, **and J. D. Smyth.** 1964. Endocrine control of encystation in *Opalina ranarum* parasitic in *Rana temporaria*. Experimental Parasitology 15:185–199.

Goldberg, S. R., C. R. Bursey, E. W. A. Gergus, B. K. Sullivan, and Q. A. Truong. 1996. Helminths from three treefrogs *Hyla areniclor, Hyla wrightorum,* and *Pseudacris triseriata* (Hylidae) from Arizona. Journal of Parasitology 82:833–835.

Harwood, P. D. 1930. A new species of *Oxysomatium* (Nematoda) with some remarks on the genera *Oxysomatium* and *Aplectana,* and observations on the life history. Journal of Parasitology 17:61–73.

Jaslow, A. P., and R. C. Vogt. 1977. Identification and distribution of *Hyla versicolor* and *Hyla chrysoscelis* in Wisconsin. Herpetologica 33:201–205.

Joy, J. E., and C. A. Bunten. 1997. *Cosmocercoides variabilis* (Nematoda: Cosmocercoidea) populations in the eastern American toad, *Bufo a. americanus* (Salientia: Bufonidae), from western West Virginia. Journal of the Helminthological Society of Washington 64:102–105.

McAllister, C. T. 1987. Protozoan and metazoan parasites of Strecker's chorus frog, *Pseudacris streckeri streckeri* (Anura: Hylidae), from north-central Texas. Proceedings of the Helminthological Society of Washington 54:271–274.

———. 1991. Protozoan, helminth, and arthropod par-

asites of the spotted chorus frog, *Pseudacris clarkii* (Anura: Hylidae), from north-central Texas. Journal of the Helminthological Society of Washington 58:51–56.

———, **and D. B. Conn.** 1990. Occurrence of tetrathyrydia of *Mesocestoides* sp. (Cestoidea: Cyclophyllidea) in North American anurans (Amphibia). Journal of Wildlife Diseases 26:540–543.

———, **S. E. Trauth, S. J. Upton, and D. H. Jamieson.** 1993. Endoparasites of the bird-voice treefrog, *Hyla avivoca* (Anura: Hylidae), from Arkansas. Journal of the Helminthological Society of Washington 60:140–143.

———, **S. J. Upton, and D. B. Conn.** 1989. A comparative study of endoparasites in three species of sympatric *Bufo* (Anura: Bufonidae), from Texas. Proceedings of the Helminthological Society of Washington 56:162–167.

———, **S. J. Upton, S. E. Trauth, and C. R. Bursey.** 1995. Parasites of wood frogs, *Rana sylvatica* (Ranidae), from Arkansas, with a description of a new species of *Eimeria* (Apicomplexa: Eimeriidae). Journal of the Helminthological Society of Washington 62:143–149.

Metcalf, M. M. 1923. The opalinid ciliate infusorians. Bulletin of the United States National Museum 120:1–484.

Muzzall, P. M., and C. R. Peebles. 1991. Helminths of the wood frog, *Rana sylvatica,* and spring peeper, *Pseudacris c. crucifer,* from southern Michigan. Journal of the Helminthological Society of Washington 58:263–265.

Odlaug, T. O. 1954. Parasites of some Ohio amphibia. Ohio Journal of Science 54:126–128.

Paul, A. A. 1938. Life history studies of North American freshwater polystomes. Journal of Parasitology 24:489–510.

Prudhoe, S., and R. A. Bray. 1982. Platyhelminth Parasites of the Amphibia. British Museum (Natural History)/Oxford University Press, London. 217 pp.

Ralin, D. B. 1968. Ecological and reproductive differentiation in the cryptic species of the *Hyla versicolor* complex (Hylidae). Southwestern Naturalist 13:283–300.

Sandon, H. 1976. The species problem in the opalinids (Protozoa, Opalinata), with special reference to *Protoopalina.* Transactions of the American Microscopical Society 95:357–366.

Shannon, P. R. 1988. The parasites of breeding male eastern gray treefrogs, *Hyla versicolor* LeConte, 1825, from the Ashland Wildlife Research Area, Boone County, Missouri. Master's Thesis, University of Missouri, Columbia.

Sullivan, J. J., and E. E. Byrd. 1970. *Choledocystus pennsylvaniensis:* life history. Transactions of the American Microscopical Society 89:384–396.

Ubelaker, J. E., D. W. Duszynski, and D. C. Beaver. 1967. Occurrence of the trematode *Glypthelmins pennsylvaniensis* Cheng, 1961 in chorus frogs, *Pseudacris triseriata* in Colorado. Bulletin of the Wildlife Disease Association 3:177.

Ulmer, M. J. 1970. Studies on the helminth fauna of Iowa. I. Trematodes of amphibians. American Midland Naturalist 83:38–64.

Vanderburgh, D. J., and R. C. Anderson. 1987a. The relationship between nematodes of the genus *Cosmocercoides* Wildie, 1930 (Nematoda: Cosmocercoidea) in toads (*Bufo americanus*) and slugs (*Deroceras laeve*). Canadian Journal of Zoology 65:1650–1661.

———, **and** ———. 1987b. Preliminary observations on seasonal changes in prevalence and intensity of *Cosmocercoides variabilis* (Nematoda: Cosmocercoidea) in *Bufo americanus* (Amphibia). Canadian Journal of Zoology 65:1666–1667.

Vogt, R. C. 1981. Natural History of Amphibians and Reptiles of Wisconsin. Milwaukee Public Museum and Friends of the Museum, Milwaukee. 205 pp.

Whitaker, J. O., Jr. 1971. A study of the western chorus frog, *Pseudacris triseriata,* in Vigo County, Indiana. Journal of Herpetology 5:127–150.

Wichterman, R. 1936. Division and conjugation in *Nyctotherus cordiformis* (Ehr.) Stein (Protozoa, Ciliata) with special reference to the nuclear phenomena. Journal of Morphology 60:563–611.

Williams, D. D., and S. J. Taft. 1980. Helminths of anurans from NW Wisconsin. Proceedings of the Helminthological Society of Washington 47:278.

Yoder, H. R., and J. R. Coggins. 1996. Helminth communities in the northern spring peeper, *Pseudacris c. crucifer* Wied, and the wood frog, *Rana sylvatica* Le Conte, from southeastern Wisconsin. Journal of the Helminthological Society of Washington 63:211–214.